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Rootstock influences photosynthetic activity, yield, and berry quality in Manjari Naveen grape

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ABSTRACT

A study was conducted at the ICAR-National Research Centre for Grapes, Pune, Maharashtra, during 2020-2023 to investigate the impact of different rootstocks on the growth, photosynthetic activity, petiole nutrient content, yield, and quality of Manjari Naveen grape. It was observed that grapevine rootstocks are essential for the overall productivity and quality of grapes. Manjari Naveen grapes grafted on Dogridge (*Vitis vinifera* L.) rootstock exhibited good fruitfulness. Dogridge rootstocks produced the highest yield and grape quality. However, 110R rootstock demonstrated high TSS. There was no significant influence on the uptake of nitrogen, phosphorus, and potassium among different rootstocks. Additionally, 140Ru rootstock was observed with higher photosynthetic activity compared to the other rootstocks.

Key words: *Vitis vinifera* L., Dogridge, Growth, Petiole nutrient, Bunch weight.

INTRODUCTION

Grape (*Vitis vinifera* L.) is an important fruit crop in the country. It grows on an area of 1.62 lakh hectares with an average productivity of 21.00 MT/ha, resulting in approximately 34.45 lakh metric tonnes of grapes annually. The primary grape growing regions in India are Maharashtra (70.67%), Karnataka (24.49%), Tamil Nadu (1.43%), Andhra Pradesh (1.34%), Madhya Pradesh (1.02%) and Mizoram (0.50%). These regions account for 99% of the nation's grape production (Anon, 1). Commercial grape cultivation in the country faces challenges related to soil salinity and chlorides in irrigation water. Various rootstocks are used to grow grapes to overcome these issues. Grafting is the primary method used to sustain grape production, and it involves using suitable rootstocks.

Grape rootstocks such as Dogridge, 110R and 1103P are being used in Maharashtra and Karnataka to combat issues such as salinity, drought, nematodes, and poor fruitfulness. Rootstock is becoming increasingly popular in Indian Viticulture due to its ability to thrive in abiotic conditions such as drought and salinity, as well as its potential to enhance scion physiology and morphology (Satisha *et al.*, 14). The rootstock is an important tool for controlling vine growth and productivity in addition to addressing soil issues. The growth of the vine is more dependent on the interaction between the stock and scion than on either one alone. Therefore, a rootstock that is beneficial for one cultivar in a specific environment may not be helpful for others in the same way (Hartmann *et al.*, 7). It is thus necessary to investigate how the rootstock suitable for a given cultivar and location that affects the plant development, production, and quality. The present study was therefore conducted to study the impact of rootstock on grapevine development, production, and quality in Manjari Naveen grape variety.

MATERIALS AND METHODS

The study was conducted at the ICAR-NRC for Grapes, Pune (18.32°N and 73.51°E) during three years (2020-21, 2021-22 and 2022-23). Three-year-old Manjari Naveen, a table grape variety was grafted on four different rootstocks (110R, 140Ru, 1103P and Dogridge). The vines were trained to Y-Trellis system of training with a spacing of 9 ft × 5 ft., thereby accommodating 968 vines per acre. The vines were pruned twice in a year: once in the summer (known as back pruning) to develop canes for fruit bud differentiation and second pruning on the mature canes after five to six months later (called forward pruning) to encourage bunch development. Five vines were selected and tagged under each replication. The means of five vines was calculated for each parameter, which includes growth parameters like pruned biomass, fruitful canes and stock: scion ratio, photosynthetic activity parameters, photosynthetic rate, stomatal conductance, internal CO_2 concentration and transpiration rate, yield and quality parameters like numbers of bunches/vine, average bunch weight, 50 berry weight and yield (kg/vine), berry diameter, TSS and acidity, nutrient content parameters like nitrogen, phosphorous and potassium. The weather data during the trial period was also recorded (Figs. 1, 2 and 3). The experiment was laid out in Randomized Block Design (RBD) with five replications. Data were

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subjected to statistical analysis as per the method given by Panse and Sukhatme (11).

RESULTS AND DISCUSSION

Manjari Naveen grafted on 1103P had significantly highest pruned biomass (1.29 kg), followed by Dogridge and 110R rootstocks, whereas 140Ru (1.12 kg/vine) had the lowest pruned biomass (Table 1). The vine vigour generally influences pruning weight. Highly vigorous vines yield more pruning biomass compared to less and moderately vigorous varieties. Pruning weight tends to increase as the crop ages (Menora, 9). In terms of rootstocks, it was noted that vines grafted on Dogridge and 1103P showed statistically similar pruning weights to each other. Satisha *et al*. (14) conducted a study on the impact of rootstocks on the vegetative characteristics of Thompson Seedless grape. They reported a wide range of pruning weights, which supports the findings of the present investigation.

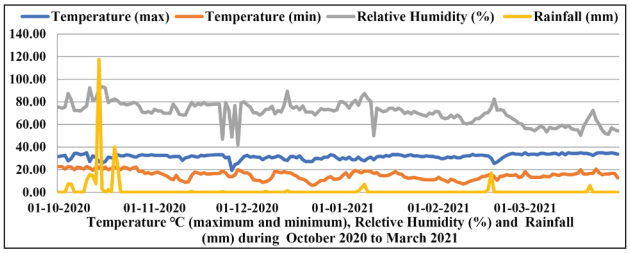

Fig. 1. Mean weather parameters during the fruiting period (October 2020 -March 2021).

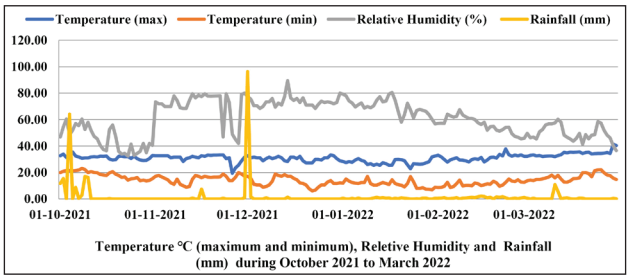

Fig. 2. Mean weather parameters during fruiting period (October, 2021-March 2022).

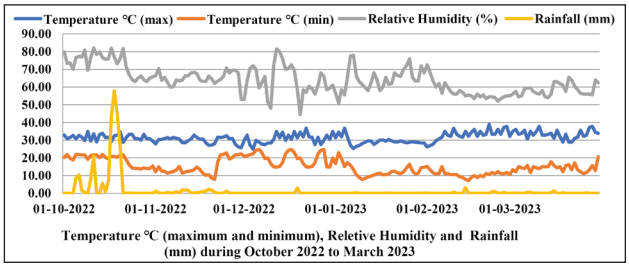

Fig. 3. Mean weather parameters during the fruiting period (October 2022 -March 2023).

Table 1. Rootstock influence on the growth parameters of Manjari Naveen grapevines (pooled means for three years).

Rootstock	Pruned biomass (kg/vine)	Fruitful cane (%)	Stock: scion ratio
110R	1.18	92.8	0.81
140Ru	1.12	88.3	0.87
1103P	1.29	93.8	0.81
Dogridge	1.21	94.4	0.83
SEm (±)	0.01	0.49	0.01
CD at 5%	0.04	1.49	0.02
Sig.	**	**	**

The pooled analysis showed that Manjari Naveen grafted on Dogridge (94.4%), 1103P (93.8%) and 110R (92.8%) had the highest fruitful canes, while 140Ru had the lowest. The direct impact of rootstock on fruit bud development and, subsequently, on crop yield is linked to the rootstock's ability to produce cytokinins. It is a widely recognized fact that cytokinins are produced in the roots, and a higher ratio of cytokinins to gibberellins is advantageous for the formation of fruit buds (Mullins, 10). Tambe (19) reported the highest percentage of fruitful canes (70.41) in Tas-A-Ganesh grapevines grafted on Dogridge rootstock.

Manjari Naveen grafted on different rootstock had a significant impact on the stock-to-scion ratio. It was observed that 140Ru recorded the maximum stock-to-scion ratio compared to other rootstocks, while the rootstock Dogridge was closely behind. The longevity of composite plant combinations is greatly influenced by the stock: scion ratio. A high stock: scion ratio can cause delayed incompatibility, highlighting the importance of accurately estimating it when predicting the long-term survival of a graft union (Verma *et al.*, 21). Differences in the genetic composition of the rootstock may also be responsible for variations in the stock-to-scion ratio when the same cultivar is grafted on different rootstocks (Ghule *et al.*, 6).

The results (Fig. 4) revealed that vines grafted on Dogridge (109.94 DAP) had the shortest time to harvest, while 1103 P (115.87 DAP) took the longest time. The findings of the present investigation are similar to the research results of Somkuwar *et al.* (16) for Manjari Naveen grapevines that were grafted onto Dogridge rootstock showing minimum days to harvest.

The impact of different rootstocks on the photosynthetic activity during the flowering stage of Manjari Naveen grapevines is presented in Table 2. From pooled analysis, it became evident that the choice of rootstock had a significant impact on the photosynthetic rate. The highest recorded

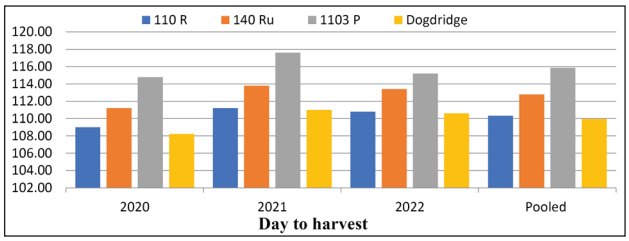

Fig. 4. Rootstock effects on days to harvest.

photosynthetic rate (13.59 µmol CO_2 $m^{-2}s^{-1}$) was consistent with the performance of 140Ru rootstock, which was statistically on par with 110R rootstock (13.20 µmol CO_2 $m^{-2}s^{-1}$). On the other hand, the lowest photosynthetic rate was observed in grapevines grafted onto 1103P rootstock (9.37 µmol CO_2 $m^{-2}s^{-1}$). However, the results on stomatal conductance did not reveal any significant differences among the rootstock. The photosynthesis rate and stomatal conductance could potentially be affected by factors such as genotype of the rootstock, the characteristics of the root system, and the overall vigour of the vine. The rootstock plays a crucial role in influencing vegetative growth by modifying the absorption of water and nutrients. It also could alter the biochemical composition of the vine, aiding in the accumulation of sufficient food resources which in turn, may contribute to an increase in the photosynthetic rate of the vine (Somkuwar *et al.*, 18). Somkuwar *et al.* (15) observed that Sauvignon Blanc grapevines grafted onto 140Ru and Fercal rootstocks exhibited the highest photosynthetic rates.

Significant impact was observed for internal CO_2 concentration using different rootstocks. Manjari Naveen grape grafted onto 140 Ru had the highest internal CO_2 concentration (275 ppm), followed by 1103P (267.3 ppm), while 110R rootstock had the lowest internal CO_2 concentration (190.4 ppm). Similarly, the highest transpiration rate in Manjari Naveen grapevines on 140Ru (3.27 mmol H_2O m^{-2} s^{-1}) with the lowest rate was observed in vines grafted on 110R (1.99 mmol H_2O m^{-2} s^{-1}). When the concentration of carbon dioxide rises, there is a corresponding increase in the rate at which carbon is assimilated into carbohydrates during the light-independent phase of photosynthesis. Consequently, the overall rate of photosynthesis tends to rise until it is constrained by other limiting factors as noted by Benckiser (2).

Similarly, Flexas *et al.* (5) reported that the rate of transpiration primarily relies on factors related to the root and water activity, which exert a significant influence on the leaf gas exchange parameters since water serves as a crucial substrate in photosynthetic processes. The findings are closely similar to the results reported by Somkuwar *et al.* (18) and Bica *et al.* (3), who noted that changes in gas exchange parameters could be attributed to the foliar biomass and leaf area of the scion canopy.

The number of bunches/vines in Manjari Naveen grapevines varied significantly with different rootstocks (Table 3), and the significantly highest number of bunches/vine was recorded in Dogridge (39.60). In contrast, the lowest number of bunches was observed in 140Ru (36.40). Manjari Naveen grapevines grafted on Dogridge had the highest average bunch weight (406.77 g), while the lowest bunch weight was on 110R (367.23 g). Somkuwar *et al.* (16) noted that Manjari Naveen grafted on Dogridge rootstock with the least bunch load had the highest average bunch weight. During the study period, rootstock shows a significant impact on the yield of Manjari Naveen grapes. The data showed that the Manjari Naveen grapevine grafted on Dogridge rootstocks produced the highest yield (16.07 kg/vine), while the lowest yield was recorded in 140Ru (13.91 kg/vine). According to Tambe and Gawade (20), Tas-A-Ganesh grafted on Dogridge (4.18 kg/vine), followed by Thompson Seedless grafted on Dogridge (3.89 kg/vine) had the highest yield. Rizk-Alla *et al.* (13) discovered that Red Globe vines grafted on Dogridge, followed by Salt Creek rootstock, had a higher yield per vine.

Manjari Naveen grape grafted on Dogridge and 1103P rootstocks had the maximum berry diameter

Table 2. Rootstock influence on photosynthetic activity of Manjari Naveen grapevine (pooled means for three years).

Rootstock	Photosynthesis rate (µmol CO_2 m^{-2} s^{-1})	Stomatal conductance (mmol H_2O m^{-2} s^{-1})	Internal CO_2 concentration (ppm)	Transpiration rate (mmol H_2O m^{-2} s^{-1})
110R	13.20	0.19	190.4	1.99
140Ru	13.59	0.24	275.0	3.27
1103P	9.37	0.16	267.3	2.37
Dogridge	12.25	0.19	237.1	2.24
SEm (±)	0.2	0.02	2.2	0.012
CD at 5%	0.6	0.06	6.9	0.038
Sig.	**	NS	**	**

Table 3. Effect of rootstock effects on yield of Manjari Naveen grape (pooled means for three years).

Rootstock	No. of bunches/vine	Avg. bunch wt. (g)	50-berry wt. (g)	Yield (kg/vine)
110R	38.60	367.23	258.65	14.13
140Ru	36.40	383.53	275.34	13.91
1103P	36.80	402.32	273.82	14.78
Dogridge	39.60	406.77	286.15	16.07
SEm (±)	0.27	2.56	1.86	0.20
CD at 5%	0.82	7.9	5.73	0.61
Sig.	**	**	**	**

(17.83 and 17.70 mm, respectively), while 110R (16.97 mm) had the minimum diameter of berry (Table 4). Significant differences in total soluble solids (TSS) were observed in Manjari Naveen grapevine grafted on different rootstocks. The highest TSS level was observed in 110R (17.21), while the lowest was in 140Ru (16.17). The results related to the acidity level were non-significant among the rootstock. TSS levels in berries were affected by various factors, including the duration between pruning and harvest, as well as the yield per vine (Menora, 9). When the yield of grapes on a vine increases, the total soluble solids decreased due to nutrient competition. Somkuwar *et al.* (16, 17) also found similar results in Sharad Seedless and Manjari Naveen grapevine grafted on Dogridge rootstock. Acidity levels in grapes are affected by temperature during their development and ripening process. Cooler temperatures tend to increase the production of malic and tartaric acids, while hotter temperatures decrease the overall level of acidity in the grapes (Karibasappa *et al.*, 8). Varying ranges of acidity levels have been reported in different studies (Ethiraj and Suresh, 4). The juice acidity was found negatively correlated with its TSS (Ratnacharyulu, 12).

The Manjari Naveen grapevine grafted on different rootstock showed non-significant variation for the nitrogen and phosporus contents, while the results were significant for the potassium content (Table 5). The highest potassium content was recorded in vine grafted on Dogridge (2.35%), while lowest in 1103P (1.50%).

Our study found that rootstock selection significantly affects various aspects of Manjari Naveen grape cultivation. Differences in growth, photosynthetic activity, nutrient content, yield, and grape quality were observed among the rootstocks. Dogridge performed the best, leading to significant improvements in yield and berry quality. The rootstock 110R had higher TSS and absorption of essential minerals, while 140Ru showed superior photosynthetic activity. These findings highlight rootstock selection as critical importance in grapevine cultivation, providing valuable insights for grape growers.

Table 4. Effects of rootstocks on quality of Manjari Naveen grape (pooled means for three years).

Rootstock	Berry diameter (mm)	TSS (°Brix)	Acidity (%)
110R	16.97	17.24	0.57
140Ru	17.35	16.17	0.55
1103P	17.70	16.59	0.56
Dogridge	17.83	17.02	0.55
SEm (±)	0.12	0.22	0.006
CD at 5%	0.38	0.67	0.016
Sig.	**	*	NS

Table 5. Petiole nutrient content of Manjari Naveen grapevine at flowering stage (pooled means for three years).

Rootstock	Nitrogen (%)	Phosphorus (%)	Potassium (%)
110R	0.90	0.47	1.60
140Ru	0.82	0.41	1.57
1103P	0.83	0.43	1.50
Dogridge	0.93	0.42	2.35
SEm (±)	0.04	0.015	0.033
CD at 5%	0.11	0.044	0.101
Sig.	NS	NS	**

AUTHORS' CONTRIBUTION

Conceptualization of research (RGS, AKU); Designing of experiments (RGS, AKS); Contribution of experimental materials (RGS, AKU, AKU); Field/lab experiments and data collection (AST, NAD, RGS); Data interpretation (RGS, AKS); Preparation of the manuscript (RGS, AST, NAD).

DECLARATION

The authors declare that they do not have any conflict of interest.

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